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SUGAR

as a Food

SUGAR INFORMATION, INC.

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as a Food

SUGAR INFORMATION, INC.

52 Wall Street • New York 5, N. Y.

INTRODUCTION

Sugar is one of our most familiar foods, and it is used by almost all the peoples of the world. It appears on the table three times a day and in unsuspected ways enters into a host of products — ice cream and condensed milk, baked goods, confectionery, canned and frozen fruits, chewing gums, soft drinks, hams and bacon, prepared mixes, salad dressings, preserves, and many others. In the United States and Canada we consume about eight million tons of sugar each year. It supplies about one-seventh of the total calories in our diets.

It might be supposed that a food so generally used would have been the subject of extensive research. On the contrary. It was not until 1943, when Sugar Research Foundation was formed, that the first organized studies of sugar as a food were undertaken. Since that time, research has advanced to a point at which it is possible to clarify — if not completely to explain — the role of sugar in nutrition, to disprove some common fallacies concerning sugar, and to set down well-established nutritional facts which may serve as a guide to its use.

The great variety of ways in which sugar is used emphasizes the basic fact that sugar is primarily a blending and combining agent. The amounts used in tea and coffee, or sprinkled over cereal, account for only a fraction of the total consumption. Because it is so generally used in other foods, the nature and function of all components of the diet must be understood before sugar's present place in the human diet can be properly evaluated. It cannot be singled out and studied without reference to the whole diet.

It is the purpose of this booklet to discuss presently-known facts of sound nutrition and the manner in which sugar can contribute to achieving diets adequate in every respect.

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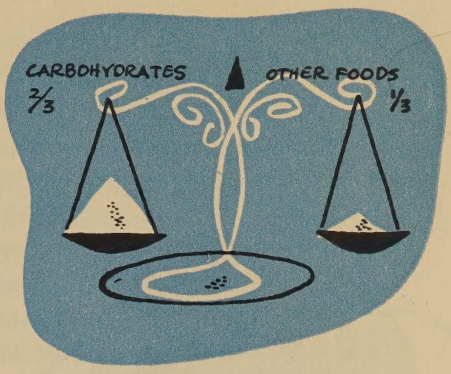
WHAT IS FOOD?



Food is nutritive material taken into the body for energy, for growth and repair of tissues, and for maintaining the vital processes. Not every article of food, of course, performs all these functions, and it is necessary, for that reason, to eat a variety of foods to obtain all the various nutrients in the balance which good health requires. Foods are usually grouped in three major classes:

Carbohydrates, which supply energy to the body.

Proteins, which are essential to growth and repair of tissues.

Fats, which provide reserve fuel and act as carriers for certain fat-soluble vitamins.

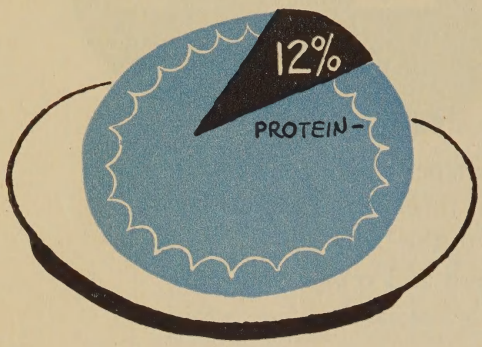
Vitamins and *minerals* are also foods because, although they do not supply energy, they are necessary to the intricate reactions involved in metabolism and the utilization of common foods for growth and repair.

THE CARBOHYDRATES

Carbohydrates, the most abundant of all foods, contain carbon, and hydrogen and oxygen in the proportions of water. Familiar carbohydrates are sugar and starch, although the group includes all substances which must be broken down into simple sugars before they can be assimilated by the body. Simple sugars, or monosaccharides, contain only a single molecule. Examples are glucose (dextrose), and fructose, (levulose or fruit sugar). Disaccharides are constructed of two molecules and include common sugar (a molecule of glucose and one of fructose) as well as milk sugar (lactose, made up of a molecule of glucose and one of galactose) and malt sugar (maltose made from two molecules of glucose). Polysaccharides are composed of many molecules of glucose. They include the starches found in vegetables and cereals, as well as dextrins and cellulose.

PROTEIN

Protein foods are the "must" of human nutrition, for life is impossible without them. Eight types of protein constituents all belonging to the family of amino acids, must be contained in the human diets. Others can be made in the body by rearranging the amino acids of animal and vegetable foods into a variety of combinations. Vegetables contain some protein, but not all the types the body needs in the right proportions. In animal foods — lean meat, milk, and eggs — protein is concentrated and the amino acids occur in ratios more adaptable to the body's requirements. About 11 to 12 per cent of the total caloric intake should contain these essential protein compounds.



Theoretically, it is possible to subsist on a diet containing nothing but protein because, in addition to providing material for growth and repair of the tissues, protein foods can be used to supply energy. Practically, however, the consumption of biologically valuable or complete proteins in amounts greater than 11 to 12 per cent of the total caloric requirements confers no significant benefits and does not contribute to good nutrition. Because of the "extra" work the body must do in changing proteins for fuel purpose, an extremely high protein diet may impose a metabolic burden to people not in good health. Moreover, protein foods are often relatively expensive and, as a consequence, the diets of the millions must contain carbohydrates and fats in greatest volume.

In the process of digestion, protein is broken down into amino acids and absorbed by the body in that form.

THE FATS

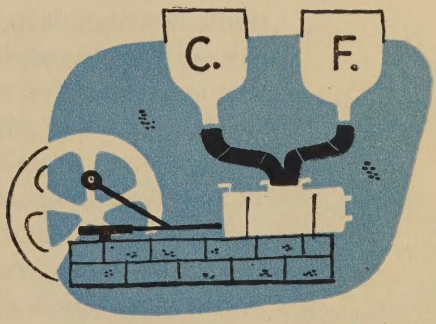
Chemically, the fats are composed only of carbon, hydrogen,

and a very little oxygen. They are so familiar that they need little description — liquids such as peanut oil, cottonseed oil, and olive oil are fats as truly as butter or lard. Little fat is strictly essential in the diet, but a small quantity of linoleic acid or a close relative must be supplied.

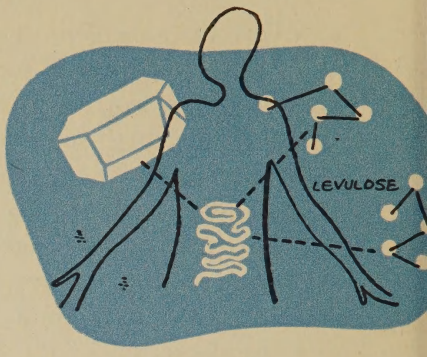
The major role of fat is to supply fuel value, or calories. Fats contribute to the satisfaction of meals through flavor and odors, and prevent too rapid a return of hunger by remaining in the digestive tract longer than proteins and carbohydrates. Fats also serve as carriers of the fat-soluble vitamins, such as A, D, and E. Fats are our most concentrated fuel foods since they provide about 288 calories an ounce, or two and a half times as much as an equal weight of protein or carbohydrate.

In the small intestine, fat is converted into "fatty acids" and glycerine. The latter, like some of the fragments from proteins, can be converted into sugars if there is a demand for fuel.

Fat is the major storage fuel of the body. When food intake is in excess of the needs of the body (whether taken as protein, fat, or carbohydrate), the excess is deposited as fat. This process can take place almost without limit so that enormous quantities of fat may be stored. Then, when food intake is insufficient to meet the caloric needs of bodily activities, stored fat is summoned. When fat is mobilized from storage in this manner, it goes to the liver where it is converted into materials called "ketone bodies." These are carried to all the tissues by the blood-stream and burned. When present in too high a concentration, these bodies cause an undesirable condition known as "ketosis." This condition occurs when too high a ratio of fat to carbohydrate, caused by too low a carbohydrate intake, is burned by the body to supply its energy requirements.



ESSENTIAL MINERALS



Since the bones and teeth are composed largely of calcium phosphate, the need for lime and phosphates is clear. Minerals are essential for the same reason as proteins. They must be supplied in minimum quantities, and nothing else can take their place.

Minerals are inorganic substances and do not provide calories or energy value. Their function is to assist in the intricate reactions which involve proteins, sugars, and vitamins to provide the hundreds of specialized compounds that the body manufactures and uses.

Salt is a familiar and essential mineral. The average man's body contains about two-tenths of a pound of salt. A liberal daily allowance for adults in good health is five to ten grams. The amount of salt in the body regulates water balance and the retention of water in the tissues. *Calcium* is required in relatively large amounts for adult men and women. Eight-tenths of a gram daily is recommended. During childhood, adolescence, and pregnancy the requirements are higher.

Iron is a mineral essential to growth and red-blood cell production. Children require from fifteen to twenty milligrams daily, the amount increasing as they grow. Adult requirements are not established, but the average diet contains enough for a safe margin.

The need for *phosphates* approximate those for calcium. Foods rich in protein and calcium usually contain phosphates in the proper proportion. Requirements are about 1-1.5 grams, and a normal good diet supplies phosphates in ample quantity. Although it is known that the body uses to good advantage certain other minerals in very tiny amounts, the only other commonly known mineral necessary is *iodine*. Regular use of iodized salt will supply all that is needed.

VITAMINS

The necessity of vitamins in the diet was not recognized until the early part of the Twentieth Century. When animals were fed diets of purified carbohydrate, fat, and protein, together with the minerals known to be necessary, it was observed that they did not grow or thrive. This led investigators to suspect that other substances, present but undetected, were necessary. In 1912, Casimir Funk isolated the first of these substances and gave them their name – vitamins. Since that time more than thirty different vitamin-like substances have been isolated, seven or eight of which are known to be necessary to man.

The discovery of vitamins, and the growing knowledge of their functions is one of the most dramatic chapters in the science of human nutrition. But these advances in knowledge have, unfortunately, been accompanied by a great deal of misunderstanding. A few facts may help to set the record straight:

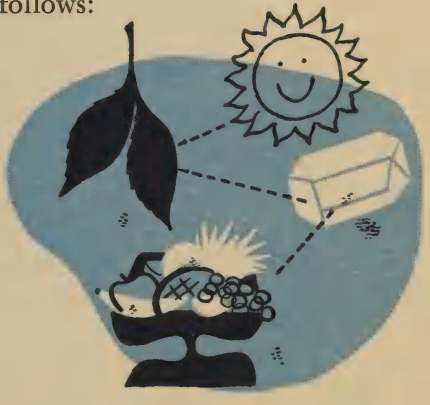
Like minerals, vitamins supply no energy or calories – they act, rather, as catalysts in regulating metabolism and body processes. Only small amounts of vitamins are required by the body, and quantities in excess of these needs are of no benefit to the normal healthy person. Good diets provide all the needed vitamins in liberal quantities and, in addition, supply other substances that are desirable but have not yet been identified. It also appears that some of the vitamins, notably thiamine, can be made by the body. The National Research Council makes recommendations for only six vitamins, as follows:

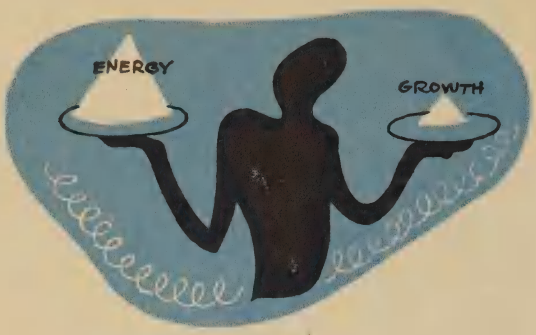
Vitamin A –found in green and yellow leafy vegetables, butter, margarine, and milk.

Vitamin B_1–(Thiamine) found in meat products, particularly organ meats and pork, and in unprocessed grains.

Vitamin B_2–(Riboflavin) supplied by milk, eggs, peanuts, and legumes.

Vitamin B_6–found in corn, wheat germ, fish muscle.





Vitamin C —present in raw potatoes, citrus juices, and fresh cabbage.

Vitamin D —present in fish and irradiated milk, but for the most part made under the skin on exposure to sunlight.

All these vitamins, with the exception of D, are provided in liberal amounts when the diets of children and adults follow the Seven Basic Foods Plan. Children benefit from supplemental amounts of D from such sources as cod liver oil. Vitamin K is also necessary, but the amounts needed have not been determined.

In purified form, the daily requirements of all these vitamins could be packed into a small capsule.

HOW THE BODY USES SUGAR AND CARBOHYDRATES

Common sugar is a natural food – the first product formed in the green leaves of all plants in the presence of light. The same sugar which appears on the table at every meal can be obtained from such familiar fruits as oranges, apples, bananas, and pineapples. The sugar cane and the sugar beet store sugar more abundantly than other plants, and they have, as a consequence, become the principal source of commercial supply. Beet sugar and cane sugar are identical products, and they may be used interchangeably for all purposes. Molasses is sugar plus organic and inorganic materials concentrated in the process of separating sugars from non-sugars in the cane juice.

Sugar is in no way changed or altered in its extraction from the plant. The refining process merely separates the sugar made by nature in the plant from the non-sugars. The nutritional value of the sugar present in a ripe peach and the sugar that may be used to preserve peaches is exactly the same. Sugar, whether obtained from the date palm, maple, pineapple, carrot, or the nectar of the flower, has a single chemical formula: $C_{12}H_{22}O_{11}$. Claims for the superiority of so-called "natural

sugars" or compared to "refined" sugars cannot be supported.

Sugar taken by mouth undergoes no chemical change in the presence of saliva. In the stomach, gastric juice begins to change sugar into two "simple" sugars – dextrose and levulose – but it is not absorbed into the bloodstream in the stomach. In the small intestine the conversion of sugar into dextrose and levulose is completed, and these products are absorbed through the intestinal wall in the portal vein, probably combining with phosphoric acid. The portal vein carries the simple sugars to the liver, the body's great chemical laboratory and its main carbohydrate storehouse. In the liver, the simple sugars are stored as animal starch, or glycogen. Levulose is stored much more rapidly than dextrose. Sugar taken by mouth is reflected in higher blood sugar levels within one to four minutes, and is consistently more rapid in its action than dextrose or levulose alone.

The adult liver and muscle tissue contain about a 12 to 16 hour fuel supply of animal starch, which is changed into blood sugars and fed into the bloodstream as the body requires. Animal starch is stored principally in the liver, but also appears in smaller concentration per unit weight in muscles and skin, where it is formed from sugars delivered by the blood. In muscle and other tissue cells, animal starch is changed into carbon dioxide and water through a complex series of chemical reactions. These reactions form a chain of intermediate products ending in carbon dioxide and water. The energy of these reactions leads to the release of heat and muscular energy.

When the skin, blood, muscle, and liver are full, any sugar excess is temporarily stored as fat. This fat is broken down in apparently continuous cycles as new fat is formed and also temporarily stored. Animal starch serves as a quick reserve of energy, fat as a more permanent reserve. Certain endocrine gland secretions, hormone products from the pituitary, pancreas,

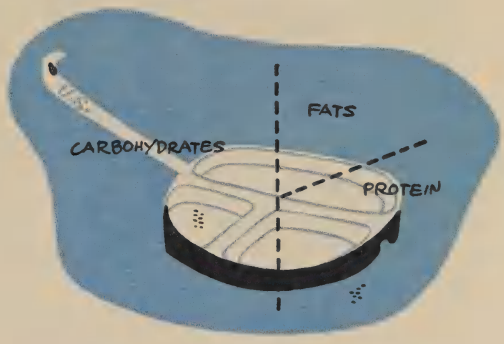
and adrenals, in some way not yet precisely charted, are necessary for the use of blood sugar by the muscle and in the formation of fat. Since 85 to 90 per cent of all food taken in by the body is used for energy expenditure, by far the greater part of all nutrients are reduced to the simple basic sugars before they can be utilized. The sugars themselves are simple compounds and their breakdown, combination and utilization are now rather well charted. Carbohydrates are often referred to as direct sources of energy, or quick-energy foods.

PROPORTION OF PROTEIN, CARBOHYDRATE AND FAT

What proportions of fat, carbohydrate, and protein should the ideal diet contain? Protein requirements have been rather well established at 11 or 12 per cent of the total caloric intake for the normal individual. Far less is known about the ideal fat-carbohydrate ratio, which combines to make up the other 88 or 89 per cent of the total calories. The Japanese, who have as much as 85 per cent carbohydrate in their diets, are vigorous and healthy. Other nations have as much as 70 per cent fat in their diet, with relatively little carbohydrates. Clearly, the composition of national diets is determined by the availability of food, and human beings over the years adapt themselves to the conditions imposed by their food supplies.

The National Research Council's table of Recommended Daily Allowances suggests 20 to 25 per cent of calories in the form of fat, although little is known about precise requirements. It appears that a 20 to 25 per cent allowance is liberal enough to provide a safe margin for the intake of valuable fat-soluble vitamins, unsaturated fatty acids, and a possible growth factor suspected in linolenic acid. Fat, too, is a valuable factor in the enjoyment of food. Observations in Germany when fat rations were low, demonstrated that a liberal supply of fat maintains morale and keeps the nervous system in a healthy state.

Other studies indicate that Americans have a relatively high percentage of fat calories in their diet and, consequently, a low percentage of carbohydrate calories. In the last thirty years, more fat has been added to our diets because people generally have eaten more meat, milk, margarine, butter, and cooking oils. At the same time, the consumption of potatoes, cereal, bread, and baked goods, has fallen off noticeably. Although there is no conclusive evidence on this point, it appears that more carbohydrate might be a valuable addition to our present diets. Clinical observations show that carbohydrate promotes fat synthesis. It also aids in the complete use of fat by the body, and spares protein for body-building and repair of tissues. The Army Quartermaster Corps suggests that a good diet will include five parts of protein, four parts of fat, and eleven parts of carbohydrate.



It does not seem likely, in view of the present dietary preferences of Americans, that we are eating "too much" sugar and starch. In well-balanced diets, the largest part has always been made up of starches and sugars. Carbohydrates are most abundantly produced by nature, and a general change to the scarcer and more expensive fats and oils or high-protein foods would not be possible even if it had been proved desirable.

What happens when there is insufficient carbohydrate in the diets of children is illustrated in a rather common complaint — cyclic vomiting. Children have a smaller liver capacity than grown-ups for storing glycogen. At the same time, they have a higher metabolism than adults, so they burn up their fuels more quickly. Whereas an adult's stock of liver and muscle carbohydrate may be sufficient for 12 to 16 hours, a child often has reserve enough for only three or four. Vomiting, upsets, or "bilious spells" of children may be caused by excitement,

unusual activity, or a delayed meal. Certain children are particularly susceptible and suffer from periodic attacks during which they cannot "keep anything down." Sometimes they are given extra quantities of cod liver oil or milk, because they appear thin and pale but, if the trouble is caused by a low storage capacity for carbohydrate, the administration of fat does more harm than good. These children often respond to between-meal feeding, particularly of carbohydrate foods such as fruit juices, candy, cookies, or soft drinks.

HOW SUGAR FITS IN THE DIET

This highly simplified outline of the role of the various elements of the diet prepares the way for a discussion of sugar and the place it occupies in the dietary pattern.

From a study of the foods recommended by nutritionists, and the amounts of protein, fat, carbohydrate, minerals and vitamins which they supply, it is apparent that we can insure a wholly adequate diet and still eat other foods to satisfy our whims or our appetites.

The science of nutrition is still in its infancy, and the human or "head" factor in diet has been given far too little consideration. People do not eat single foods or chemicals. They vary their meals to stimulate taste – to make eating a pleasant interlude – so that there are hard-to-determine psychological factors that every dietician knows are important. No matter how nutritious, people will not for long eat unpalatable foods.

The chart opposite indicates that all the recommended foods can be included daily. They will supply 1300 calories of the recommended 3000. This leaves for our further pleasure, 1700 calories to be divided between fat and carbohydrate, or additional proteins.

RECOMMENDED DAILY FOODS

of

FOOD AND NUTRITION BOARD — NATIONAL RESEARCH COUNCIL

to

ASSURE ADEQUATE NUTRIENTS IN THE DAILY DIET

* * *

MILK	one pint
EGGS	one daily
MEAT, FISH OR FOWL	one or more 4-ounce serving
POTATO	one or more
VEGETABLES	two or more servings
FRUITS	two or more — one citrus or tomato
CEREALS AND BREAD	whole grain or enriched
OTHER FOOD	to make up the caloric deficit

THESE SUPPLY:

Nutrient	*Allowance*	*Supplied by Diet*	*Surplus or Deficit*
Protein	70.0 g.	84.9 g.	+14.9 g.
Calcium	0.8 g.	0.804 g.	+0.004 g.
Phosphorus	——	1.43 g.	——
Iron	12 mg.	14.6 mg.	+2.6 mg.
Vitamin A	5000 I.U.	6411 I.U.	1411 I.U.
Vitamin B_1	1.5 mg.	1.46 mg.	—0.04 mg.
Vitamin B_2	2.0 mg.	3.36 mg.	+1.36 mg.
Vitamin C	75.0 mg.	143.0 mg.	+68.0 mg.
Niacin	15.0 mg.	13.6 mg.	—1.4 mg.
Fat	——	41.9 g.	——
Carbohydrate	——	162.2 g.	——
Calories	3000	1314	—1686

Random selections of meats, fish, vegetables, fruits, etc., were made from standard food tables and weighted averages of the content of the various nutrients were calculated. The apparent small deficits of thiamine and niacin are not significant since a slight difference in the random selections would give surpluses. The recommended allowances contain wide margins of safety.

Of course, few foods contain only a single nutrient, as the chart shows. To make attractive and tasty dishes, many of the basic foods are combined, and in these combinations, sugar is often used to accent flavors. It is clear, therefore, that once the basic requirements are satisfied, we have wide freedom in choosing whatever foods we wish to provide variety and pleasure. That sugar is as satisfactory a source of calories for this purpose as fat or extra protein has been conclusively demonstrated.

ANIMAL TESTS

A few years ago, Dr. Clive M. McCay of Cornell University placed 200 rats on a basic diet designed to supply, liberally, all known protein, vitamin and mineral requirements. This was accomplished by feeding the rats less than half the amount of their total food requirements, just as in the human diet described above. He completed the caloric requirements of four different groups by giving them, respectively:

1. Cooked corn starch.
2. Cooked corn starch 60 parts, sugar 40 parts.
3. Cooked corn starch 60 parts, dried milk 40 parts.
4. Cooked corn starch 60 parts, dried liver 40 parts.

The question he wanted to answer was: If an animal eats a truly adequate basic diet, does it matter whether he chooses the rest of his calories in the form of all starch, starch and sugar, starch and whole milk, or starch and meat? The milk and meat would, of course, supply protein and vitamins far beyond the liberal quantities in the basic part of the diet. The answer to the question was "NO," for all groups of rats completed life spans that were not significantly different:

Dietary Variable	LIFE SPAN IN DAYS *Males*	*Females*	*Total*
Starch	595	705	1,300
Sugar	674	717	1,391
Milk	688	610	1,298
Liver	531	682	1,213

In other words, there was no benefit, so far as span of life is concerned, in supplementing a truly adequate diet with even such foods as liver and milk.

Another thorough experiment was carried out in 1929 by Prof. C. M. Jackson of the University of Minnesota. Thirty-six rats were used in three groups. One group had a "normal" diet containing 45 per cent cooked corn starch, 30 per cent protein in the form of milk casein, 20 per cent fat in the form of lard, and 4.5 per cent of a salt mixture, together with concentrated vitamin sources. The vitamin sources were cod liver oil, dried yeast, and wheat germ.

A second group had exactly the same diet except that the starch was replaced by sugar. This kind of feeding was continued for two hundred days, a long period in the life of the rat. All animals remained normal in health, vigor, and appearance. Their growth in weight was normal, and there were no differences between those receiving the sugar and those receiving starch. All the female animals became mature in the usual time and had the normal numbers of offspring, which were normally nursed. When the animals were sacrificed and their internal organs examined, all were found to be in good condition.

A human being receiving the same proportion of his food as sugar would consume nearly nine ounces a day, or 200 pounds a year.

Jackson went still further. Another group of rats was placed on a diet which contained 80 per cent sugar, only 16 per cent protein (casein of milk), and 4 per cent salt mixture. Only ten drops a day of lard was given as the total fat supply, and the same supplement of vitamin concentrates.

Even these animals showed virtually the same general physical scores with only a faint suspicion of fatty infiltration of the liver, which was later found to be caused by an extraneous factor. A human being consuming sugar so that it supplied 80 per cent of caloric intake would eat 23 ounces a day, or 524 pounds a year.

TESTS WITH HUMAN SUBJECTS

The animal experiments are not isolated examples. In the course of tests for various purposes, physiologists, biochemists, and nutritionists have kept monkeys, dogs, mice, rats and other animals for months and years on diets of 66 per cent sugar by weight. It is a recognized fact among such scientists that very high sugar feeding is perfectly feasible, but with humans there seems to be no point in going as high as 66 per cent. It may, however, be practical to study under what conditions quantities of sugar up to twice our present per capita supply of 99 pounds could be worked into thoroughly satisfactory diets.

In a recent two-year study of several hundred children in Pennsylvania custodial institutions, the diet was completely analyzed and thorough clinical examinations of the children were conducted. These included almost all known examinations of eyes, teeth, bones, vital organs, blood and urine. From time to time during the period when the "free-sugar" intake of children more than twelve years of age was nearly 4½ ounces a day, the subjects were given another thorough physical examination.

In no respect was there any deterioration in the general health of the group. On the contrary, the children with the highest sugar intake showed marked superiority in growth, skeletal development, and resistance to fatigue in comparison with the groups having practically identical diets but with a lower

sugar allowance. It is noteworthy that the high-sugar group, which consumed almost three times the quantity recommended by the Children's Bureau of the United States Department of Agriculture, showed less increase in tooth decay over a two-year period than found in the general population of the same age-sex distribution. In a further study of groups of children whose diets were below minimum standards on almost all nutritional scores, it was found that the addition of sugar to a diet – without adding any other food elements – resulted in an appreciably better utilization of protein for body building and a marked increase in fat synthesis.

From time to time observations are presented which have led to some rather widely held but erroneous beliefs about sugar and general health. For example it has never been demonstrated that the amount of sugar consumed has any relationship to susceptibility to the common cold or other respiratory infections. Nor is there any firm scientific evidence to relate sugar intake to poliomyletis, cancer, tuberculosis, arthritis or heart trouble, in spite of frequent implications that there is such a connection. During World War II nutrition authorities recommended that 175 pounds of sugar per year be earmarked for members of the armed forces. If the slightest evidence existed that sugar was undesirable as part of a well-balanced dietary, those in charge of the fitness of our troops would never have insisted that it constitute such an important part of the rations.

By every test known to physiologists, sugar is as satisfactory in performing the functions of a carbohydrate as any other foodstuff which is primarily an energy food. Unquestionably, many of the complaints charged to sugar are really dietary deficiencies resulting from income insufficient to purchase the ingredients of a good diet, or from ignorance or carelessness in understanding what the body requires to operate at peak efficiency.

NUTRITION AS THERAPY

If "we are what we eat," diet may be a valuable tool in the treatment of disease and the restoration of health. Some examples will illustrate the point.

In obesity and diabetes, diet is obviously a matter of importance. Striking cures for pellagra, beriberi, and polyneuritis have been brought about by the use of vitamins. The adjustment of diet promises to alleviate the effects of the "degenerative diseases," among them arthritis and nephritis, and it is helpful in various heart disorders and acute stomach ulcers.

The therapeutic value of minerals and vitamins is rather generally understood. That, however, is not the case with carbohydrate – and the interdependence of carbohydrate, protein, and fat in special diets is still less frequently recognized. High protein diets are used in "wasting" illnesses and where there has been massive tissue destruction. In these diets, sufficient carbohydrate is needed because of its protein-sparing effect. When more protein than usual is called for, the increase cannot be made at the expense of the regular carbohydrate portion.

High protein diets are prescribed in a number of diseases. Some of them, like tuberculosis, involve a destruction of body tissue that must be rebuilt. As a consequence, not only repair but even resistance to tuberculosis seems to be heightened by a relatively high protein consumption.

Resistance to juvenile rheumatism appears also to be improved by high protein intake. In certain blood-sugar level conditions, extra protein is also indicated. It can safely be said that resistance to infectious diseases may depend in part upon a liberal supply of amino acid building blocks, since the antibodies that put up a defense against harmful microorganisms

have a protein character. Growing children may be benefitted by receiving somewhat more protein than is usual to guard against depletion caused by the irregular demands of growth.

In all these high-protein diets there must certainly be a large proportion of carbohydrate. Thus, when it is said that too much sugar and starch cause increased susceptibility to tuberculosis, it is comparable to saying that a man who starves to death is killed by drinking too much water. The facts can be more accurately stated in this way: An inadequate supply of protein may cause increased susceptibility to tuberculosis or rheumatism.

It should be noted here that there are also diseases and conditions in which a relatively low protein diet is indicated. Protein restriction had been advocated in cancer, hypertension, Bright's disease, kidney trouble, and gout. It must not be assumed that abundant starch and sugar will prevent these conditions. There is no need to worry that by eating carbohydrates we expose ourselves to tuberculosis or that by including adequate protein we succumb to cancer. The normal person need only avoid extremes.

Since a number of infectious diseases, such as diptheria, result in liver dysfunction and dehydration, diet is a therapeutic measure. Diets high in carbohydrate are indicated in many cases. The wide effects of these diseases on body metabolism have been thoroughly described in the medical literature, and physicians recognize that diet is highly efficacious during the active course of disease and during convalescence. Experimentally, it has been demonstrated that diets high in sugars have been relatively effective in helping to restore sufferers from kidney diseases, ulcers, and heart conditions. This diet, incidentally, drastically reduces protein. Whether the success is due to some effect of the carbohydrate or the absence of some aggravating substance in protein can only be decided after much more research.

In certain diseases of the liver and in preparing patients for surgery building up carbohydrate reserves is routine.

DIABETES

The administration of carbohydrate in the treatment of patients suffering from diabetes is widely accepted. Diabetes is a metabolic disorder characterized by the inability of the body to store and regulate carbohydrate, specifically dextrose. Medical authorities are in agreement that carbohydrate, or sugar, does not cause diabetes. Its causes are not well understood, but they appear to be hereditary. Whether excessive sugar can precipitate diabetes in one who has a predisposition to the disease is open to question, but it can be said that for normal people this is not true. The principal reason why the diabetic cannot regulate his sugar level, is that his pancreas produces an insufficient supply of insulin. Disorders of the other endocrine glands and of the liver may also be involved in the onset of diabetes.

The modern dietary management of diabetes consists in providing adequate protein, carbohydrate, and fat for energy purposes. At least as much carbohydrate as fat is allowed, and frequently the ratio may be as high as two to one. In cases where the patient has an unusually low insulin production and is, therefore, unable to utilize even small amounts of carbohydrate, enough insulin is supplied hypodermically to enable him to do so. This relative abundance of carbohydrate as compared with older diets seems to restore the liver to proper functioning. Since the liver is believed to be involved in the condition, the treatment may reduce the actual diabetic state. Inositol, a vitamin-like substance found in molasses and some sugar syrups, is a promising drug in the alleviation of diabetes.

Sugar has another familiar therapeutic use in the treatment of diabetics. Overdosage of insulin may result in insulin shock. Temporarily, the body's mechanism for handling insulin be-

comes surcharged. As every diabetic has been instructed, the best way to restore the sugar-insulin balance is to take a cube of sugar, a piece of candy, or a high-sugar beverage.

WEIGHT CONTROL

Although there is no scientific evidence to show that any food is peculiarly fattening, the facts about sugar apparently need restating.

Since the first experiments with crude calorimeters almost a century ago, physiologists have been able to calculate the fuel value of our common foods. These values are commonly expressed in a standard unit of measurement — the calorie — which is the amount of heat required to raise the temperature of one kilogram of water one degree centigrade. In a healthy human being, no consideration other than the caloric value of foods and the total daily intake is significant in weight determination. Proper salt balance is assumed, for an excess of salt will cause retention of excess water in the tissue for a time.

In evaluating the caloric value of foods, investigators early discovered that fats and oils contain roughly twice as many calories per pound as carbohydrates and protein. But few of our foods, as ordinarily prepared, fall into a single category. Sugar, however, which is a combining agent in the preparation of many foods, is purchased as a pure carbohydrate and therefore contains more calories than other predominantly carbohydrate foods such as cereals and most vegetables which contain some water, ash, or indigestible cellulose. A pound of sugar supplies between 1,794 and 1,808 calories. The caloric value of some other common foods follows:

	Calories Per Pound
Bacon	2,839
Beef, round medium	803
Rye bread	1,146
Peanut butter	2,808
Whole wheat cereal	1,712

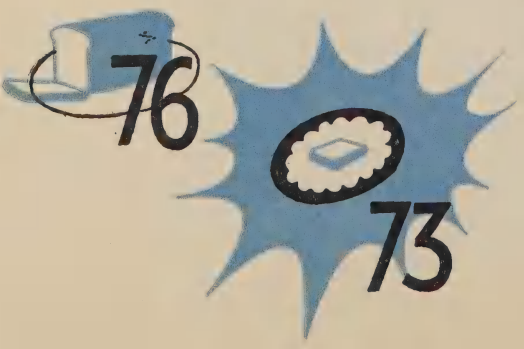
Translated into meal values, a lump of sugar contains 24 calories, an average pat of butter 73 calories, a slice of light rye bread (without butter) 76 calories, a medium-size glass of milk, 123 calories. Thus, the average daily consumption of 3½ to 4 ounces of sugar provides no more than 450 calories to the total of 3,000 required by the average, moderately active man.

If more calories are taken than the body burns, the excess — whether from carbohydrate, protein, or fat — will be deposited and stored in the body as fatty tissue. More and more physicians believe that it is not the type of foods, or the combinations in which they are eaten, that disposes to overweight. It is simply over-eating in almost every case. In the exceptions, a distinct variation in metabolic rate is often traceable to glandular conditions. These change appetite, upset metabolism, and may be responsible for a gain in weight on calories only sufficient for maintenance of weight in the normal individual.

Scientific studies show it is desirable to maintain a good level of carbohydrate because it is needed to burn up the body's stored fat. It would seem reasonable to trim portions and keep the same balance of different foodstuffs, and especially avoid an excess of fatty foods, since many Americans have a high proportion of fat in their diet.

Any reducing diet must still supply the necessary protein for tissue building and repair, and the vitamins and minerals necessary for regular activity. Most people understand this fairly well, but the fact is that some overweight patients cannot long follow a special diet or eat sensibly. In these instances, emotional or psychological factors may be involved.

It was recently reported that 95 per cent of more than 500 overweight patients under observation and treatment eventually recognized that anxiety was at the root of their overeating. In some cases, the need for stuffing themselves with food was actually so great — yet so against their better judgment — that they "forgot" their raids on the icebox and insisted they were complying with the prescribed meals and



were still not losing weight.

Doctors now believe that will power is seldom sufficient to break this type of overeating unless its emotional causes are understood. The benefits often credited to exercise and massage are now believed to be more correctly traceable to a healthier mental outlook.

Among the mental factors which may be at the root of overeating, one investigator lists the following:

1. The working of the subconscious on such things as frustration, worry, fear, or lack of emotional satisfaction. A person thus afflicted sometimes reverts to infantile behavior. At one stage, infants put everything into their mouths. This is naturally followed by the regressed adult who is continually feeding himself.

   Another manifestation of the subconscious may lead a woman to excessive eating as a means of compensating for some psychic injury she has suffered through social failure or disappointment in love.

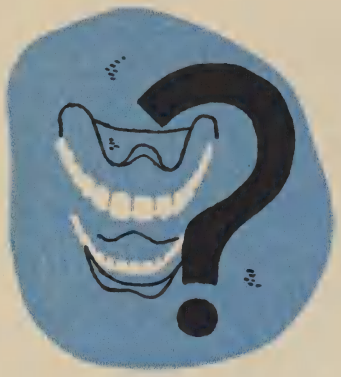
2. A conditioning to food. A child brought up in a family of big eaters may fall into the habit of taking a lot of food as a matter of course. In this same category are people who conduct business affairs over the table and who are constantly exposed to high calorie foods.

3. An aggressiveness toward food. A child reared in poverty learns to eat everything in sight because he doesn't know where his next meal is coming from. This trait may be carried into adulthood even though the individual attains economic security.

4. Monotony, boredom. Some people who lack diversions seek escape in eating. Housewives trapped by routine may nibble at food all day. Travelers who have to drive long distances may stop for food just to break the monotony.

5. Occupational temptation. People who work in food establishments are constantly tempted to eat.

6. Nervousness, social upset or family trouble.



TOOTH DECAY

Since 1889, when W. B. Miller developed what has come to be known as the chemico-parasitic theory of tooth decay, carbohydrates in general and refined sugar in particular have been widely accused as the chief culprits in tooth decay. The theory has been taken up by health writers, radio commentators, and some segments of the press.

The facts are these: Dental caries is a pathological condition whose causes are unknown, although one might be tempted to classify it as a normal condition of evolutionary origin because more than 95 per cent of the American people suffer from it in some degree. There are, however, a number of impressive theories held by dental researchers which find causes of decay in factors other than carbohydrates.

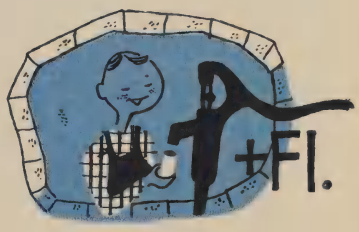
In discussions of the cause and control of dental caries, there are almost as many different theories advanced as there are researchers. That sugar in the diet is the primary cause of dental caries has never been conclusively proved. It is true that some success in reducing the rate of decay has been achieved where sugar intake, as well as other nutrients in the diet, have been changed. Yet, in view of the necessity for balance in the diet, there is serious question whether this method of attack would be nutritionally justifiable even if cutting down carbohydrates did succeed in reducing caries to an appreciable extent.

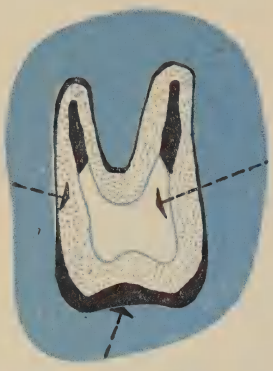
There are two principal schools of thought on the causes of caries. Proponents of the chemico-parasitic theory maintain that decay is a purely local condition — that carbohydrate is fermented by bacteria normally present in the mouth to form an acid which attacks the enamel. The other group insists that dental health is intimately related to generally good diets and maintains that structurally sound teeth will not be susceptible to acid attack if, indeed, it is an acid attack that causes decay. Some also believe decay starts inside the tooth.

From long-term observations made under the supervision of the United States Public Health Service and other investigators it appears that children who have access to drinking water containing one to two parts per million of fluorides will have less than half as much decay as those whose drinking water contains no fluorides. Fluoride solutions may also be applied directly to the surface of the child's teeth as a preventive measure. A series of applications is advised, generally at the ages of 3, 7, 10 and 13, but the time of application varies with the individual child and depends on the rate at which the teeth erupt. An application at 3 years of age provides protection for the "baby" teeth. Subsequent applications provide protection for the permanent teeth, the incisors and first molars at age 7, the bicuspids and cuspids at age 10, and the second molars at age 13.

Since teeth which contain small amounts of fluoride salts have a much higher resistance to decay than fluoride-deficient teeth; the logical aim of research should be to add these and other presently-unknown protective elements to the diet, rather than attempting to eliminate inexpensive, and palatable carbohydrates. It has been said that man lives for other purposes than to build a good set of teeth. If this has to be done by avoiding common foods, it stands little chance of success.

Since the problem of tooth decay requires far more study than it has had in the past, Sugar Research Foundation has been assisting a number of projects designed to fill gaps in our knowledge. One of these is a long-range study being carried out by Dr. J. D. Boyd of Iowa State University. Dr. Boyd believes that many of the older studies of dental caries are not acceptable because of unsound statistical methods. By taking into consideration all environmental factors, Dr. Boyd's research can be expected to give a definite answer to the question of whether the relatively high sugar content of a diet, in which all of the necessary nutrients are supplied, produces tooth decay.





New types of dentifrices containing ammonium ions are regarded with optimism in some quarters as promising caries control. Preparations containing penicillin have also shown promising results. Further experience will be required with these in order to determine their efficacy.

Most hopeful of all is the discovery that proper nutrition of mothers, before birth of a child and during the nursing period, can have a tremendous influence on the resistance of their children's teeth. The exact nutritional requirements for creating this resistance are not yet known, but the way seems to have been cleared for discovering them, and further progress may be expected.

Some well-meaning dieticians advocate the use of honey, raw sugar, brown sugar, maple sugar, or dried fruits in place of refined sugar as a means of preventing tooth decay. This doctrine has no sound scientific basis. All fruits contain the same kind of sugar which is commercially recovered from beets and cane, and all ferment with equal ease. In dried fruits, such as figs, dates, and raisins, the proportion of sugar is high — just as high as in most cakes and candies. (See Table on page 27.) Hence, strict adherents to the simple acid-fermentation theory of tooth decay must eliminate from their diets not only refined sugar but also honey, raw sugar, brown sugar, fresh fruits, dried fruits, and all fruit juices.

The progress of preventive dentistry has always been handicapped by woefully insufficient financial support. Since people do not die of tooth decay, the disease has never been given the attention it deserves as a source of discomfort, expense, pain, and the origin of more serious complications. Moreover, even though tooth decay has its chemical, biochemical, bacteriological, physiological, nutritional, and histopathological angles, few scientists in these fields have until recently become interested in the problem. In these days, all related sciences are expected to collaborate with the medical profession in bringing about progress in medicine. Similar teamwork, greatly expanded

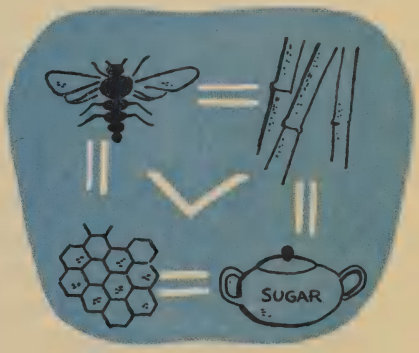
beyond its present scope, will be necessary for final solution of the tooth decay problem.

COMPARISON OF SUGAR CONTENT OF DRIED FRUITS AND PREPARED SWEETS

Comparison of Sugar Content of Dried Fruits and Prepared Sweets

Dried Raisins	64.4%
Dried Dates	63.9
Dried Currants	63.1
Dried Peaches	53.0
Dried Figs	52.9
Dried Apricots	43.4
Dried Prunes	40.3
Milk Chocolate	54.5
Chocolate Cake	29.8
Ice Cream	17.5
Apple Pie	17.3
Rice Pudding	10.9
Cola Drinks	10.5

1. The term sugars here includes sucrose, glucose and fructose.
2. These figures are from McCance and Widdowson, *The Chemical Composition of Foods,* Chemical Publishing Co., Inc., New York 1947.



SPECIAL USES OF SUGAR

In certain situations, sugar is particularly valuable as a food. During World War II, many pilots and bombardiers "blacked out" at high altitudes, particularly on returning from long missions. So many unexplained accidents occurred to bombers which had escaped enemy damage and were nearly home that investigations were made.

The trouble was traced to *alkalosis.* The blood ordinarily remains almost constant in its acidity. The slightest change either toward the more acid or toward the more alkaline causes trouble. The proper acidity of the blood is maintained in part by carbonic acid, a weak acid formed from carbon dioxide and water. If the blood is charged with more carbon dioxide gas, its acidity increases slightly. Any influence that removes carbon dioxide from the blood faster than normal shifts its reaction to the alkaline side.

One way to remove carbon dioxide from the blood is deep breathing, which makes the blood slightly more alkaline. In other words, deep breathing produces alkalosis. A severe alkalosis results in giddiness, and loss of consciousness.

Something similar happens when the rarefied air of high altitudes is breathed over a period of time. The relatively low concentration of oxygen requires deep breathing to provide enough, and carbon dioxide is lost at an increased rate. A sudden giddiness caused by alkalosis can result in accidents.

The remedy was simple. Carbohydrate foods, including sugar, are those which most quickly and efficiently charge the blood with carbon dioxide. High carbohydrate breakfasts just before the take-off were shown to increase the "ceiling" of fliers by as much as a thousand feet. In addition, an air lunch composed principally of candies, proved its efficacy in pre-

venting alkalosis during the homeward flights. There was, of course, plenty of time for eating fats and proteins between missions.

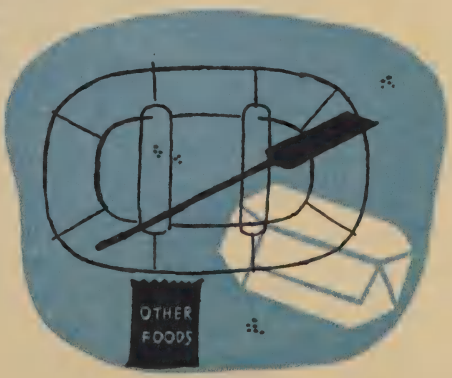
A parallel situation is found in life-raft rations, where the physiological problems are first to get enough calories to sustain life and, second, to conserve the body's water.

To the man on the raft, burning up the fat he has stored in his body is not important because the loss of fat will not affect his ability to gain it back later. However, the undue wasting away of his muscles and organs is decidedly important since his future health depends on the soundness of these tissues.

His problems, then, physiologically speaking, are to burn fat but to spare protein. These conditions require that his principal food be carbohydrate. Readily-burned carbohydrate "spares" his body protein from being drawn upon to supply indispensable blood sugar. Carbohydrate also permits combustion of fat without excessive ketosis. The special disadvantage of ketosis on a life-raft is the fact that surplus "ketone bodies" in the blood cause an excessive output of urine which wastes precious fluid. It may also produce vomiting.

All life-raft rations are largely sugar with small quantities of protein to aid in maintaining tissues, a minimum of fat for satiety value, and vitamins.

Recently a sterile invert sugar made from common sugar has been developed for intravenous administration. The results of full-scale animal tests and extensive clinical trials on human subjects indicate that the equal mixture of levulose and dextrose in solution has marked superiority over routine dextrose administration. The first reports in the medical literature show that speed of administration – getting calories into the patient in a shorter space of time – is a proved advantage. Undoubtedly this is due to the fact that the liver adsorbs the levulose fraction of sugar from the blood stream approximately two and one half times faster than it adsorbs dextrose alone.



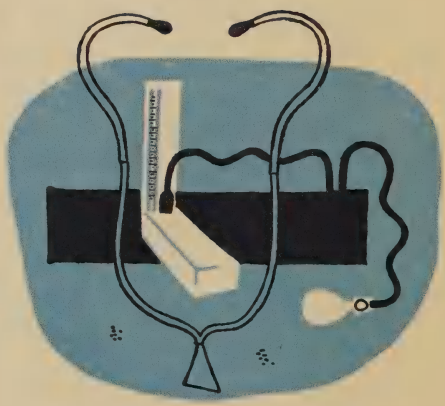
THE "RICE DIET" FOR HIGH BLOOD PRESSURE

The causes of chronic high blood pressure are not yet well understood, and *reasoned* methods of prevention and treatment are not highly developed. Nevertheless, a method of control, discovered largely by accident, is giving remarkable results. This is the so-called "rice diet" which was developed by Dr. Walter Kempner of Duke University.

A report, based on experience over four years, with more than seven hundred patients suffering from high blood pressure shows that 70 per cent of the cases obtained relief.

The "rice diet," apparently does not depend on any specific ingredients found in rice itself. Nor does the diet consist wholly of rice, for it contains generous quantities of sugar and fruit. It could equally well be described as a high-carbohydrate, low-fat, low-protein regimen. Rice protein is believed, however, to be particularly high in biological value and, perhaps, particularly beneficial to the metabolism of kidney cells. Dr. Kempner also believes that no other diet can be devised with so low a salt content, and this is generally agreed to be one principal reason for its success.

The total caloric value is low — about 2,000 calories a day. Of this, fat constitutes only about 5 grams (45 calories or 2.2%). Twenty grams of protein are contributed by the rice and fruit, or 80 calories (4%). The rest is carbohydrate. Salt is reduced to 2½ percent of the average consumption.



The Kempner diet is high in sugar. The average allowance is 100 grams daily (3½ ounces), but where fuel requirements are greater as much as a pound may be used.

Not only has the diet been effective in treating high blood pressure, but it brings considerable relief in cases where enlarged hearts, tissues swollen with fluid, and other complications exist. It is, of course, dangerous for any patient to prescribe the diet for himself, and even physicians do not recommend it unless they are in a position to follow carefully the changes in blood and urine during the period of treatment. Bed rest is not usually necessary.

SUGAR AND THE LIVER

The liver is the body's principal storehouse for carbohydrate. Though a number of different carbohydrates are taken in with food, all are broken down into simple sugars in the small intestine and are absorbed into the blood at various rates and with varying degrees of efficiency.

Glycogen, the storage form of sugar in the liver, has also some other quite remarkable functions. It somehow regulates the rate of production of ketones from fat. When the liver is depleted of glycogen, a greatly increased ketone production occurs.

Glycogen also plays a somewhat mysterious role in protecting the liver and the rest of the body from poisons. Many mildly poisonous substances, such as borneol and menthol, are eliminated from the body through the urine. In the urine they no longer occur in the free state but are found to have become combined chemically with glucuronic acid, which is a close chemical relative of glucose and glycogen. It may be presumed that somehow the liver is able to draw on glycogen for formation of glucuronic acid and then to link this with the poison, producing a more soluble and more easily eliminated combination.

Physicians have learned that a good glycogen store protects the liver against damage by chloroform and some other mildly poisonous anesthetics. On this account, as well as for other

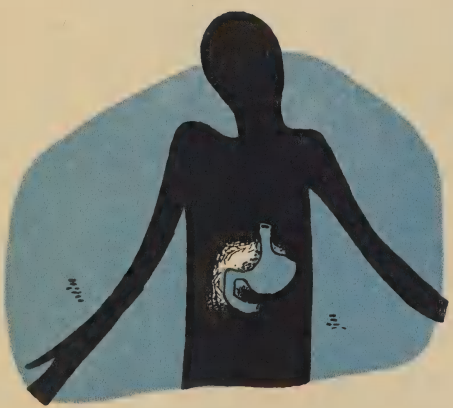
reasons, it has become customary to administer sugars intravenously to surgical patients prior to operations.

A great many poisons are carried to the liver for disposal, and the presence of an ample supply of glycogen nearly always aids in the process. Painters are often exposed to benzene. After long periods of exposure, various amounts of liver tissue may undergo degenerative changes, first a "fatty infiltration" and then a hardening or "cirrhosis." In general, relatively high carbohydrate feeding has been considered valuable in counteracting these changes and in restoring liver tissue that has not yet been severely damaged. Dietary fat tends to speed the effects of the poisons.

Certain protein constituents, notably choline and methionine, aid in preventing fatty degeneration of the liver. Cirrhosis is now kept under control, often with great success, by the use of diets very high in protein and carbohydrate but low in fat.

Again, poisons such as the dye called "butter yellow" not only produce liver damage but also seem to predispose to cancer. In these cases also, carbohydrates help to protect the liver and delay the onset of cancer while fats appear to have the opposite effect.

During the war, when thousands of persons were working in munitions plants and were exposed to vapors of nitrotoluene and had skin contacts with this and other toxic explosives, many cases of mild poisoning were encountered. Symptoms such as chronic headache were relieved by high-carbohydrate low-fat diets. Sugar is naturally used liberally in such diets.



The levulose fraction of sugar seems to have a particular relationship to the liver. Research has shown that levulose is taken up by the normal liver at a rate two and one half times faster than dextrose for the formation and storage of glycogen.

LOW BLOOD SUGAR

The theory that high-carbohydrate or high-sugar foods cause an undue increase in blood sugar levels, followed by a marked drop with consequent lassitude or "let down" feeling has been thoroughly investigated. It appears that the research which led to the formation of this theory was based on a small number of subjects who were not metabolically normal. More recent experiments show that, in the average person, high carbohydrate meals do maintain energy. People with low blood sugar level do not seem to be benefitted by a switch to higher protein foods which, at one time, were believed to "stick to the ribs" longer. Those with constitutionally-low blood sugar are given special diets by their physicians, which may include high-protein feedings.

Several years ago, there was considerable interest in a development which purported to find patients with low blood sugar more susceptible to poliomyelitis. Authorities, however, failed to find cause or relationship between low blood sugar and onset of polio, and in no case could a relationship between high-sugar diets and polio be found.

SUGAR IN INFANT FEEDING

Almost since the beginning of artificial feeding of infants, the benefits of adding carbohydrates to animal milk have been recognized. The earliest experimenters used sugar to supply calories, and for more than a century it has been a standard ingredient in formula-feeding, both in hospitals and private practice.

The emergence of the science of pediatrics has been marked by broad investigations into all aspects of formula feeding. As a result, it is now general practice to supplement the carbohydrate naturally present in the milk, so that the total carbohy-

drate in the formula accounts for 45 to 65 per cent of all calories. This brings about a more rapid recovery of birth weight, better retention of water and minerals, firmer muscles, and more fatty tissue. However, the chief advantage of the carbohydrate supplement is that the milk protein of the formula becomes available for growth and repair of the tissues, and need not be used in the expenditure of energy.

In recent years a number of claims have been made for the superiority of different kinds of carbohydrates in infant formulas. Among them are milk sugar, corn starch derivatives, malt-dextrose mixtures either as powder or syrup, glucose, banana sugar, and honey. There is no evidence to show that any of these products possessed distinct advantages over common sugar. On the contrary, many leading pediatricians and government publications recommend sugar because of its nutritive value, low cost, availability, and ease of preparation. The more expensive and "fashionable" proprietary preparations, which are so widely advertised, appear to offer nothing to offset their higher cost. Sugar can be used – and with less fuss, less bother, and less strain on the family pocketbook.

Refined, granulated sugar contains no vitamins or minerals. Assays, however, show that neither is raw cane juice a naturally rich source of either vitamins or minerals, therefore, the amounts lost in the refining process would very probably not justify the costs of retaining them. Besides, the small quantities that are lost are amply supplied by other foods with which sugar is used in the diet which contain relatively concentrated amounts.

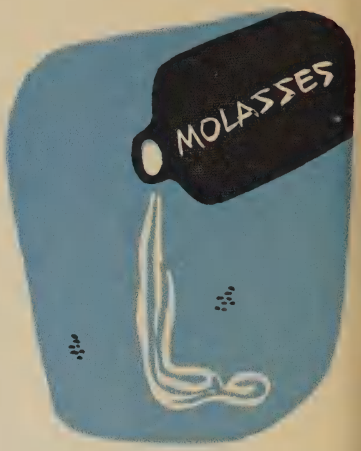
BROWN OR SOFT SUGARS

The familiar brown sugars are not raw sugars as so many

people seem to believe. In the trade these sugars are generally known as "soft" sugars.

In the refinery, raw cane sugar is first washed to remove the film of adhering raw syrup and then dissolved in water. The solution is processed to remove micro-organisms, fiber, gums and coloring matter. From such clarified solutions, several "crops" of pure, white refined sugar can be crystallized by evaporation at low temperature and separation in centrifugal machines.

As the refined sugar is removed by crystallization, the remaining syrup or mother-liquor becomes progressively darker because of the concentration of coloring matter not removed by the earlier processing. Some additional colored substances are formed by the action of heat on glucose and fructose and the interaction of these sugars with amino-acids, derived from the original cane juice. The simple sugars, glucose and fructose, are present in the original juice and, like the non-sugar substances, they accumulate in the refinery syrup by concentration, as white sugar is removed by crystallization. Some of the substances formed from the glucose and fructose contribute to the familiar delectable flavor of brown sugar. Mineral substances contained in the cane juice, including calcium, phosphates and iron, are likewise accumulated in the refinery syrup. After the last crop of white sugar is separated, this is "boiled" to a very fine crystal grain which, even after centrifuging, holds within its mass a substantial proportion of the yellow or brown, mineral-rich syrup (molasses), from which the crystals were formed. Brown sugars are not washed in the centrifugal machine as are white sugar, so a maximum of molasses is retained in the final product. These "soft" sugars are marketed as yellow, light yellow, golden brown, light brown, old fashioned brown, etc. They are clean, wholesome products and are fully refined in the sense that the undesirable impurities in the raw sugar have been removed.



The "soft" or brown sugars, especially the darker ones, may be far richer in mineral matter (ash) than the raw sugars from which they were made, because of the concentration of non-sugars described above. For those who wish to get all possible minerals in the diet, brown sugar may be used on cereals, and fruits and with other foods where its molasses flavor will not interfere with desired flavor notes.

Molasses which is a rich source of minerals, particularly calcium, iron and other fractions of possibly valuable nutrients, is recommended by many nutritionists. A tablespoonful three or four times a week is considered a good natural dietary supplement.

CONCLUSION

Sugar as it is used in the modern well-selected diet fulfills all the physiological functions of a carbohydrate food. It is easily assimilated by the normal healthy person. No other common food is more rapidly available for energy expenditure. It provides calories at lower cost than other familiar foods and combines with many valuable foods to enhance their taste appeal. At present levels of consumption sugar does not displace "protective" foods, and with some care in the selection of meals, it is possible to accommodate much larger quantities of sugar than we now use without any risk to optimum nutrition. The body utilizes white refined and brown sugars by the same processes that it does for honey and the so-called natural sugars.

Sugar has been blamed for conditions which are more correctly attributable to an inadequate diet. There is no substitute for an adequate diet containing all the known essential amino acids, vitamins, minerals, and a liberal caloric allowance of fat and carbohydrate in proportion. Research has shown, however, that a diet that contains all essential materials is not incompatible with a diet which is high in sugar.

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